# STUDIES ON POWDERY MILDEW OF SOME ECONOMICALLY IMPORTANT PLANTS

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BY

**PRITI ROHATGI**

DEPARTMENT OF BOTANY
ALIGARH MUSLIM UNIVERSITY
ALIGARH (INDIA)

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DEPARTMENT OF BOTANY
ALIGARH MUSLIM UNIVERSITY
ALIGARH.

**CERTIFICATE**

This is to certify that Ms Priti Rohatgi has worked in this Department as a Research Scholar under my supervision and guidance. Her work on the "Studies on powdery mildew of some economically important plants" is upto-date and original. She is allowed to submit her Dissertation for the consideration of the award of the degree of Master of Philosophy.

Mohd. Akram

(Mohd. Akram)
M.Sc., Ph.D.(Alig)
F.P.S.I.

DEDICATED

TO MY

BELOVED PARENTS

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Priti Rohatgi

( PRITI ROHATGI )

# I N D E X

# INTRODUCTION

Umbelliferae being a family of the angiosperms with more than 200 genera & 2,900 species, are cosmopoliton in distribution in every type of climate. The chief centres of the distribution are found in North temperate region.

Family umbelliferae is of fairly great economic value, some plants, produce fruits which are used as condiments, while others are of medicinal importance. The important plants are Coriandrum sativum, Cuminum cyminum, Foeniculum vulgare, Daucus carota, Trachyspermum ammi, Apium graveolens, Anethum graveolens, Ferulaassa foetida, etc. Carrots are a very good source of Carbohydrates, vitamines and minerals especially vitamines A & D details of some are as follows:-

Coriandrum sativum (Dhania) - The fruits are stimulant, Carminative and antibilious. The seeds are chewed to correct foul breath.

Cuminum cyminum (Zira) - The fruits are stimulant carminative, astringent and are useful in dyspepsia & diarrhoea. They are used in Cookery and in veterinary medicine. The seeds are used in snake bites.

Foeniculum vulgare (Sonf) - The roots are used as a purgative and the leaves are often cooked and eaten. The oil from seeds is used as a vermicides. The fruits which are eaten with betels and also used as a condiment.

Daucus carota (Carrot) - Carrot seeds are used for adulterating "bhang". Carrot helps the elimination of uric acid. Carrot is a rich source of fat soluble hydrocarbon, vitamines A, B, C, D & E calcium and phosphorus. Cooking bring about the considerable loss in the nutrient value of carrots. Pressed juice from Carrots is used as a blend for orange juice to give a palatable canned beverage. The white varieties of Carrots are valued as feed for horses and dairy cattle. Carrot tops have a high manurial value when ploughed into the land. The carrot in useful in disease of kidney.

Apium graveolens (Ajmud) - They are used in bronchitis asthma and for liver and spleen disease.

Trachy spermum ammi (Ajwain) - The plants are used both as a condiments as well as for its medicinal properties, the fruits being carminative.

Anethum graveolens (Sowa) - The fruits are used as a condiments while the leaves are eaten as sag. The fruits are also of medicinal value and are largely used as a remedy for the colic in horses.

Ferula assa - foetida (Hing) - It is used for flavoring curries, sauces and pickles. Medicinally it stimulates the intestinal and respiratory tract and the nervous system. It in useful in asthma, whooping cough and chronic bronchitis. It is also administered in hysterical affections and in cholera.

The members of family umbelliferae are attacked by the different diseases by different pathogens such as virus, fungus, Bacteria, nematodes etc. Among these the powdery mildew, a fungal disease is more prevalent on the members of this family.

Members of family umbelliferae were found infected with Erysiphe heraclei (Decandolle and Delmark, 1821). De Bary (1870) however, recognized it as E. umbelliferarum which was later confirmed by Went (1882) on Carrots (Daucus Carota L.). E. polygoni on cumin (Cuminum cyminum) and Coriander (Coriandrum sativum), E. umbelliferarum on Carrot, fennel (Foeniculum vulgare) and on Dill (Anethum graveolens L. ). Mathur et al. (1974) while confirming the views of Nour (1959) suggested that powdery mildew fungi of Umbelliferous hosts should be called as E. umbelliferarum.

Vegetable rank next to cereals as source of Carbohydrates in addition to sources of vitamines and minerals. In amongst the different vegetables. The cultivation of carrots can be dated back of over 2000 years.

Considerable work has been carfied out on the umbelliferous powdery mildew both in India and elsewhere (Vasudeva, 1960; Kapoor, 1967; Nour, 1957; Clare, 1958; Kable and Ballantyne, 1963; Blumer, 1933, 1967; etc.).

In the views of the above cited literature. It is considered desirable to study the following:

1. To survey the incidence and severity of powdery mildew on different umbelliferous crops.
2. Identification of the causal organism on the basis of conidial and perithecial characters, if any.
3. Effect of different relative humidities and temperatures on the germination of conidia of the powdery mildew of members of Umbelliferae caused by Erysiphe heraclei DC.
4. Effect of different temperatures and relative humidities on the development of powdery mildew on detached leaves.

5. Host range of powdery mildew of umbelliferae within the members of the family and out side the family.

6. To study the effect of different fungicides on the control of powdery mildews.

## REVIEW OF LITERATURE

The term 'mildew' used alone in an unfortunate one, since a great variety of fungi is some times called mildews. Since 1986 the term 'powdery mildews' has been commonly limited to the peronosporaceae.

The word powdery mildew was recognized and named as early as 1753 by Linnaeus, the pathogen which causes powdery mildew comes under the family Erysiphaceae. The member of this family are easily recognize since they form a white powdery mass on the surface of the host.

Powdery mildew of Erysiphaceae are those fungi with (Colourless or hyaline) hyphae. Powdery mildew are already defined family of obligate parasitic ascomycetous fungi. The term "mildew" used alone, is an unfortunate one, since a great variety of fungi is some times called "mildews".

The Erysiphaceae cause the disease known as powdery mildew, they have earned the name because of the enormous number of Conidia produced on the surface of the host. These appear to the unaided eye as a white powdery coating. These are termed as Conidia, when the germinated conidia entered through stomata form a net of mycelium beneath the epidermal cells. The fungus attack the stem and young leaves, the

latter becoming chlorotic and may be killed. A few species of powdery mildews are only known to produce perithecia, many produce only conidia. Fruits on infected plants either do not set and if setting is there, they ripen prematurally and lack the texture, flavour and sugar contents.

Powdery mildew are common on various nonumbelliferous hosts. Powdery mildew has been reported on large number of crops. Salmon (1900) in his "Monograph of Erysiphaceae" listed about 1500 species as the host of powdery mildews. Weiss (1950) recorded powdery mildews on 1340 out of 3100 host species shown in U.S.D.A. index plant disease. Jenson (1951) pointed out that powdery mildew caused 42 percent reduction in the yield of barley. Powdery mildew fungi have by and large wide host range. Blumer (1967) observed powdery mildews on 1928 plant species belonging to different families of angiosperms.

The considerable amount of damage due to powdery mildews has been reported on large number of crops and at times it exceeds 20 percent. Jagger (1926); Milbrath (1927) and Mckeen (1954) reported heavy losses in yield of Muskmelon due to powdery mildew, while Szembel (1930) and Tafradzhilski (1959) reported it very destructive to cucum-

ber. Last (1957) pointed out that powdery mildew caused 68 percent reduction in the yield of barley. A reduction of 33 to 90 percent has been reported in grapes (Arnaud and Arnaud, 1931) and 90 percent in peaches (Fikry, 1936).

Heavy losses due to this group of fungi have also reported by Cannon (1962) on potatoes; by Palm (1921), Alexandroff (1927), Minev (1957), Wober (1959) and Cole (1964) on tobacco; Ganguly and Pandotra (1963-64) on mint and by Moore (1956) on pepper. Matta and Garibaldi (1969) observed severe losses to crops of dill in the Albengaregion of Italy. Similar losses occured to fennel crops (Niviello, 1961), which is an increasingly essential oil crop in Southern Italy. In India Uppal et al. (1935) reported severe losses due to Powdery mildew on pea. In case of severe infection, even one picking is not possible against 6-7 pickings from a normal crops.

In 1963 Munjal et al. observed that, on the powdery mildew of pea, the loss we proportional to the disease intensity between the limits, 50-100 percent. Gupta and Dalela (1962) reported that powdery mildew caused 83 percent losses in late sown Coriander crops. Similar heavy losses were reported by Srivastava et al. (1971) on these crops with reduction in seed yield, losses the colour and seed quality.

## IDENTIFICATION OF THE PATHOGEN AND HOST RANGE

Majority of the powdery mildew, including the species attacking Umbellifers, seldon produce perfect stage in nature, therefore criteria other than the perfect stage such as, the colour of the mycelium, presence or absence of fibrosin bodies and production of germ tube or appressoria like bodies were resorted to for establishing the identity of powdery mildew by various workers. Salmon (1900) named powdery mildew on Umbelliferous host as E. polygoni. Later Nour (1959) preferred the name E. umbelliferarum because of the shape of the conidium is cylindrical. Mathur et al. (1974) were also of the views that Powdery on umbelliferous host is E. umbelliferarum. Kapoor (1967) reported E. heraclei DC. an umbelliferous crops & distinguished it from the other species of Erysiphe in having elongated cylindrical conidia and numerous short irregularly branched appendages in the cleistothecia.

Komirha (1933) recorded E. umbelliferarum f. anethi on fennel (Foeniculum vulgare) from Russia and considered it identical with the powdery mildew on dill (Anethum graveolans).

However, Gupta *et al.* (1982) reported *E. heraclei* infecting carrots in India, *E. heraclei* on carrot, fennel, parsely and parship seed has been reported by Noviello (1961), Boerema *et al.* (1964). Hirata (1966) reported fine umbelliferous crops viz. angelica, celery, dill, fennel and Parsely have been found to be severely infected with *E. heraclei* in Japan *E. umbelliferarum* has a narrow host range, Nour (1959). *Daucus carota* and *Faba bona*, which has more or less identical conidia, gave negative results when the conidia from former host were deposited on leaves of later even at optimum atmospheric conditions. Marras (1961) distinguished three host specialised strains of *E. umbelliferarum* on carrot, fennel and parsley on the basis of conidial measurements. Abiko (1981) while testing a large number of plants concluded that *E. heraclei* from carrot infected only carrot.

However, isolates of *E. heraclei* from *Chenopodium ambrosioides* and *Torilis japonica* did not infect carrots. *Leveillula taurica* has been reported to infect coriander in Sudan (Boughey, 1946) and Pakistan (Khan and Kamal, 1962). Chorin and Patil (1962), however, reported *Oidiopsis taurica* (*L. taurica*) on carrot in Israel.

Chen and Chen (1981) observed highest germination of Conidia of E. heraclei between 20-32°C. Cleistothecia of E. heraclei on Daucus carota were observed late in the season i.e. during April - May. Chen and Chen (1981) pointed out that the germination of conidia of E. heraclei on carrots occured at 20 percent relative humidity.

The germination of conidia of E. umbelliferarum from D. carota or Pahabona was inveriably very poor. Conidia of E. umbelliferarum (which are apparently to very short lived) gave poor germination even at saturation.

Rajderkar (1966) observed that the production of Cleistothecia of E. umbelliferarum on carrot was very high when exposed to low temperature or to alternating wet and dry conditions within the range of 25-27°C.

E. polygoni, as such has a very wide host range and this aspect led Blumer (1933) to conclude that it is an aggregate species. In India Uppal and Desai (1933), Arya (1957) and Chona et al. (1960) have reported E. polygoni on Cumin (Cuminum cyminum) and Coriander (Coriandrum sativum) and E. umbelliferarum on Carrot (Daucus carota). E. polygoni on Coriander has also been reported in India by

Anonymous, (1950), Gupta and Dalela (1962) and Srivastava et al. (1971). Vasudeva (1963) reported cleistothecia of E. polygoni on Carrot seeds.

Most crop in this family (Umbelliferae) are attacked by Erysiphe heraclei, also reffered to as Erysiphe umbelliferarum (Kapoor 1967b), hosts include Carrot fennel, parsely and other umbellifers. There is a world wide distribution (Hirata, 1966). Six biological forms were distinguished by Hammerlund (1925) while Marras (1961) recognized three host strains on Carrot, fennel and parsely.

In Great Britain occassional infection are seen on Carrots. Howkins and Phillips (1960) found out breaks in the black ten region of East Anglia which caused little obvious crop loss but encouraged pre-mature foliar senscence. Severe infections were also seen on East Anglion Crops following the dry summer of 1976 (Dixon, unpublished data). The same authors reported the disease as having occured at Jersy and Berneaux (1965) reported the disease in France.

Late sown crops were specially affected, disease losses of 83% were recorded. Similar heavy losses were reported by Srivastava et al. (1972) in Rajasthan, India, there was reduction in seed yield and also loss in the colour and seed quality of Coriander.

L. taurica will also cause Powdery mildew disease of Coriander. It was reported by Khan and Kamal (1962) in Pakistan who noted white powdery patches on the abaxial leaf surface and yellowish discolouration on the upper surface. Lessions gradually turned brown and became obvious, ultimately the leaves died and fell off.

Records of infection by the imperfect oidial stage occur for all the crops described and have been summarized by Hirata (1966). Seed transmission of E. heraclei on carrots, fennel, parsely and parship seed (Noviello, 1961; Boerema et al., 1964; Noble and Richardson, 1968 and Perri, 1969).

Abercrombie (1977) noted that Powdery mildew Erysiphe polygoni, was identified on 183 acres of carrots (Daucus carota Var. saliva) in the santa Maria valley of the central coast of California.

The carrot powdery mildew usually attacks palestinian Carrots when 10-12 weeks old and will especially severe on winter sown crops (Rayss, 1940). Various recommendations for chemical control have been reported notably the use of maneb and morestan mixture and triphenyttin compounds. The disease still a problem since Netzer and Katzer (1966) estimate powdery mildew (E. umbelliferarum) as one of the two major foliar

diseases of Israeli carrots. In Mediterranean regions carrots are infected, Thus Matta (1962), describes out breaks on three carrot cultivars; Nantes, Palescan and Nautes X Palescan in experimental plots at Turin, Italy, references will also made to the perfect stage and the pathogen named as E. polygoni.

A granding system was given for disease evolution and formulae for calculating percentage disease index and control, sprwying with sulphur fungicides produced some measure control.

In recent years parsnip crop in great Britain have been severly infected with powdery mildew (Presumably E. heraclei): use of fungicides gave no significant yield response but there was a trend towards increase total weight and longer root size in sprayed plots. In cultivars trials Avonresister remained relatively uninfected compared to most other commercially available cultivars. (Dixon, 1974).

Srivastava et al. (1971) observed the powdery mildew of coriander cause 15-20% loss in Rajasthan. The different fungicides Casan, sultaf, Karathane WD, elosal, thiovit and moracide. The sprays are essential to obtained satisfactory results.

Grosse and Forsch (1990) have reported the control on powdery mildew by silica and fungicides, the infected barley shows better effect than silica. The content of N and P

increased in the straw with severity of mildew attack. The mineral nutrients will not influenced by the treatments.

Kato & Toshiro (1983) observed the mechanism of action of the fungicide buthiobate. Buthiobate is effective in Controlling powdery mildews of agricultural and ornamental crops. Microscopic observations indicated that the fungicide caused abnormal swelling of germ tube of Sphaerotheca fuliginea with out inhibition of spore germination.

Laws et al. (1983) pointed out the germination and growth of single pustule isolates of Erysiphe graminis tolerant and sensitive to tridemorph and ethirimol. In the absence of fungicides neither tridemorphnor etherimol tolerant isolates different from the sensitive in germination or colony growth. The presence of tridemorph retarted the growth rate of colonies of tolerant and sensitive, isolates but the germination of tridemorph tolerant isolates was less depressed than that of the sensitive isolates by high concentration.

Yarwood (1978) pointed out the moving particles of vacuoles of Erysiphaceae. The brownian movement was observed in conidia of Erysiphe cichoracearum.

Occurrence and control of powdery mildews on a few plants in Assam. (Roy, 1973). Powdery mildew caused by Oidium have recorded on a number of plants. The infection was

mostly confined to the upper surface of leaves occassionally spread on the lower surface at the later stage and in extreme cases did extend to other green aerial parts.

Keshwal et al. (1981) observed the effect on powdery mildew by different dates of sowing and fungicidal spray. The Erysiphe polygoni will lower in early sowing. The effective control was with the 3 applications of sultaf (0.25%). Kujani (1983) reported that the liquid sulphur preparation against powdery mildew of parsley. In Erysiphe umbelliferarum the sulphur 900 FW and sulphur at $5^{1}$/ha reduced infection to 0.15 and 0.17%. The thiovit S and Rubigon 12 EC to 0.63 and 0.24%.

Bonnet (1983) pointed out that the Daucus carota L. sub sp. dentatus Bertol the source of resistance to powdery mildew for breeding. The inheritance of resistance from D. carota is the crosses controlled by the dominant gene.

Bedlan (1985) reported the potassium deficiency on downy mildew (Plasmopara crustosa), powdery mildew (Erysiphe heraclei and Leveillula taurica) and various soft-rots and storages-disease.

Paulus et al. (1985) observed the control of Erysiphales and observed that propiconazole and fenarimnol controlled Sphaerotheca fuliginea on cucurbits. The intermediate control was also obtained.

Puzanova (1985) observed the biological control of the pathogens of Powdery mildew of plants. The 125 spp. of plants infected by powdery mildew in the krasnodar region. Out of these 88% also bear spp. in the test of Cucumber leaves infected. When 0.2% ampelomycin was sprayed 3 times at intervals of 12-14 days on cucumber in the glass house, control was 88.2, 98.5% effective.

Vulsteke and Meeus (1986) observed the optimum number of fungicide sprays on Scorzonera. Three or four sprays with triademefon + chlorothalanil or tridemorph + fentin hydroxide controlled Erysiphe cichoraceaarum and improved yield.

Bayleton an effective systemic fungicides for controlling powdery mildew of wheat (Kavr and Jhooty, 1984).

The inhibitory effect on some phylloplane fungi on powdery mildew disease development has been reported by Srivastava and Suman (1986). The effect of aqueous suspension of eight phylloplane fungi on the germination of

powdery mildew conidia (Erysiphe cichoracearum DC. and development of powdery mildew disease on Cucurbita maxima.

A revision of Erysiphe polygoni sensu from India E. polygoni as described from India was found to comprise 8 spp.; E. berberidis, E. betae, E. heraclei, E. martii, E. pisi, E. polygoni, E. ranunculi and E. salviae by Paul & Kapoor (1986).

## ENVIRONMENTAL AND POWDERY MILDEW

The different environmental factors on powdery mildew reviewed by Yarwood (1957) and Schnathorst (1965). It was claimed that the development of Powdery mildew was generally favoured by light. The factors that will be treated are temperature, moisture, light and wind. Warm humid weather (Anonymous, 1946 and 1950); green house conditions as against out door conditions, (Steiner, 1908 and Tucker 1952), hot, dry weather (Wager 1937); Sandy soils (Manasson, 1955). Other factors such as atmospheric pressure, smoke, air, circulation and soil fertility have been reviewed by Yarwood (1965). Out of the various environmental factors temperature, moisture, (Delp, 1954; Yarwood, 1957 and Schnathorst, 1965) and soil fertility (Yarwood, 1959) appear to have a profound effect on the development of powdery mildew.

Chen (1981) observed highest germination of conidia of E. heraclei between 20-32°C. The powdery mildew have an optimum temperature for germination and growth of about 21°C which is several degree lower than the average optimum for plant pathogens. The minimum, optimum and maximum temperature for development of powdery mildew. Optimal temperature for germination, infection and growth in the powdery mildew tend to approach the optimal temperature for the host. The cool weather plant such as cereals and lettuce are attached by mildews.

Moisture is another important factor which influence the germination of Conidia, infection and growth of powdery mildews formation and maturation of perithecia.

Schnathorst (1965) critically reviewed this aspect and pointed out that in place of relative humidity, moisture stress as determined by vapour pressure deficit is more indicative of the response observed in germinating mildew conidia. Vapour pressure deficit has been shown to be more precise than relative humidity on a measure stress, in either case the temperature should always be given. This deficit (VPD) can be determined from psychrometric reading. It can be calculated by the formula VPD = (1-RH) E,

Where E is the V.P. at saturation at a given temp, and RH is the relative humidity. The deficit changes if temp. changes.

On the basis of VPD, schnathorst (1965) divided the powdery mildews into three categories, based on their response to moisture stresses.

Hashioka (1937) reported that more infection occured at 96% RH than at 97 or 100% and at 69% as against 55°C. Massee, 1903; Blodgett, 1913, 1915; Brisley, 1926; Beeley, 1932; Moore, 1936; Fisher, 1938; Bremer, 1940; Parris, 1949;

on the other hand, reported, favourable effect of rain, dew (Easthem and Ruhan, 1924; Fisher 1938; Ubrizsy); Fogy weather (Carter, 1915; Ballard et al. 1914) and sprinkling water (Reeves and Blodgett, 1949; Sprague, 1955), on powdery mildew.

Moisture greatly influence the germination of Conidia, the infection and the development of powdery mildews.

Buchheim (1928) and Blumer (1948) reported that the formation of perithecia occured only under low moisture conditions. Schnathorst (1959) reported the formation of functional perithecia at 13°C, 60% relative humidity and 900 ft. Candles illumination and in saturated atmospheric conditions at 23°C with 300 ft. Candles illumination. Salmon (1903), Yossifovitch (1923) and Moseman et al. (1957) reported that free water was essential for the maturation of ascospores.

According to Deslandes (1954) a relative humidity of 85 percent was optimum for infection and sporulation in powdery mildew. At low humidity there was not only a decline in germination but a reduction in mean germ tube length. Morrison (1964) observed that free water on leaf disc surfaces inhibited the germination of conidia of large number of powdery mildew fungi, but high relative humidity favoured the germination.

Nour (1953) studied the effect of different relative humidities on percentage germination of conidia of various powdery mildew fungi. The germination of conidia of E. umbelliferarum from Daucus carota or Faba bona was invariably very poor even at saturation. However, conidia of E. umbelliferarum (which were apparently very short-lived) gave poor germination even at saturation.

Rajderkar (1966) observed that the production of cleistothecia of E. umbelliferarum on Carrot was very high when exposed to low temperature (0.5°C and 9°C) or to alternating wet and dry conditions within the range of 25-27°C, when treated with certain vitamines or 10-25 percent sucrose. Malik et al. (1973) reported that under Aligarh conditions formation of cleistothecia of E. heraclei on D. Carota was observed late in the season i.e. during April-May. Chen and Chen (1981) pointed out that the germination of conidia of E. heraclei on Carrots occured at 20 percent relative humidity. The conidia germinate from 20-30°C on 2 percent water agar plate with optimum temperature at 28°C.

The conidia of powdery mildew fungi have been found to germinate at a wide range of pH but higher germination has been observed at pH 6.6 to 7.0 (Yarwood, 1957).

It has been observed that both infection and incidence of powdery mildew were severe under dry rather than under wet climatic conditions (Wager, 1937; Anonymous, 1945; Boughey, 1949; Palti; 1953). D. Angremond (1924); Blumer (1927); Deslands (1954) and Morrison (1961) reported that high relative humidity favoured the incidence of powdery mildew. Brisley (1926); Beeley (1923) Moore (1936); Fisher (1938); Bremer (1940) and Parris (1949) were also of the opinion that overhead irrigation favoured the development of powdery mildew. Schnathorst (1959) reported that the growth of mycelium was abnormal, when a film of moisture was present on the surface of the epidermis. Yarwood (1939); Schnathorst (1959) and Morrison (1961); on the other hand, reported that film of free water did not favour the development of the powdery mildew. Salmon (1903), Yussifovitch (1923) and Moseman et al. (1957) observed that free water was essential for the maturation of ascospores. Disease epidemic of Powdery mildew on artichoke are associated with limited rainfall and decreasing autumum temperatures, cultivars which have almost entire leaf blades and no spine are most resistant than those with lobate leaves (Ciccarone, 1953).

Severity of mildew is positively correlated with plant vigour and that any soil or their factor which promote plant vigour also favours the development of powdery mildew (Arnaud and Arnaud, 1931; Smith and Blair, 1950).

Spinks (1913), Schaffnit et al.(1930), Trelease and Trelease (1928) and Mansson (1955) found that low nitrogen and high potassium had reduced the development of powdery mildew. Cole (1964, 1966). On the other hand, reported plants grown in water-culture fortified with all the elements were more susceptible to Erysiphe cichoracearum than those grown in which the ratio of potassium and nitrogen was low.

Laibach (1930) and Homma (1937) reported that low nutritive condition of host favoured the development of Perithecia. The formation of ascospores of E. graminis according to Arya and Chenawat (1953) was fascilitated by submerging abortive perithecia in dilute nitric acid, sucrose and potassium nitrate.

Geary and Wall (1977) pointed out powdery mildew on Carrots. At out break of the oidium stage of E. heraclei on Carrot in Norfolk (1975).

Komaxis (1977) recorded a new disease of Carrot, the occurence of E. polygoni on Carrot in imperial count y in U.S.A. Wu, Ws (1978) observed the powdery mildew of Carrot in Taiwan as E. Polygoni.

Karis (1985) observed the data on 106 spp. of Erysiphales, including Erysiphe, Microsphaera, Phyllactinia, Podosphaera, Sphaerotheca and Uncinula on 640 host spp. in 11 regions. The distributed in North Eastern Asia.

Paul and Kapoor (1985) observed the taxonomy of anamorphs of Erysiphaceae. The collection of powdery mildew in conidial stage from tropical or near tropical region. The ascospores are rarely, the teliomorph is also in modern terminology, presently the conidial stage of Erysiphe. The powdery mildew occuring in their Conidial stage only.

Umbelliferae family are not free from the infection of powdery mildews and considerable amount of damage to Crops is done every year. The review of literature clearly explains that very little attempt has been made to study the causal organism of the powdery mildew on carrot systematically. Moreover, nothing is known about the incidence of the factor affecting the development of disease. In view of above facts, it was considered desirable to study the following:-

1. To survey the incidence and severity of powdery mildew on different umbelliferous crops.

2. Identification of the causal organism of Powdery mildew and measurement of conidia and conidiophore.

3. Effect of different relative humidity and temperature on the germination of conidia of the powdery mildew on members of Umbelliferae caused by Erysiphe heraclei DC.

4. Effect of different temperature and relative humidity on the development of powdery mildew on detached leaves.

5. Host range of powdery mildew of Umbelliferae in the respective families and out side the families.

6. To study the varietal resistance of different cultivars against the powdery mildew.

7. Effect of systemic fungicides for the control of powdery mildew.

8. Estimation of sugars and nitrogen in susceptible and resistant plants in order to correlate it with the disease.

## EFFECT OF DIFFERENT FUNGICIDES ON POWDERY MILDEW

### POWDERY MILDEW FUNGICIDES

A. Sulphur:- Sulphur used is reviewed by Mc - Callan (1967) and Sharvelle (1969). Sulphur was used in ancient time as a medicine and as a fumigant. Element sulphur remains the predominant fungicide for the control of grape powdery mildew. Sulphur treatment is cheap.

Sulphur is applied mainly as a fine dusting powder at rates which vary between 5 and 40 kg. sulphur $ha^{-1}$. A small proportion of Kaolin and bentonite is commonly added to prevent the tendency of the particles to clump together. Wettable Powder and Colloidal liquid formulation are also available; these usually contain 60-80% sulphur. They are diluted with water and applied in high volume sprays at about 1000-10000 ppm sulphur, or in spray at correspondingly increased concentrations. Lime sulphur made by boiling at aqueous suspension of calcium hydroxide with sulphur, is a concentrated solution of calcium polysulphides together with a little calcium thiosulphate. On mixing with water and exposure to air the product decomposes to a fine suspension of sulphur particles.

Sulphur is also applied by volatilisation. Vapour tends to control mildew better on the upper leaf surfaces than on the under sides.

Sulphur exerts its fungicidal action at the surface of leaves, stems, flowers or fruits to which it is applied. It is redistributed over such surfaces to a limited extent by vaporisation and also by the action of rain and dew. It does not penetrate into plants or move through them to an extent sufficient to protect the new parts of the plant which appear after treatment and which are often highly susceptible to powdery mildew. It must be applied repeatedly to protect these new tissues and so offset losses caused by weathering. On grape-vines 8-12 applications per season are commonly made. Coating of sulphur on treated plants will for some time protect them from infection by hindering or preventing the germination of powdery mildew spores.

Powdery mildew grow mainly on the plant surface, applied sulphur can come into direct contact with existing mycelium and suppress its growth and sporulation. Sulphur tends to work better in warmer countries.

Sulphur does penetrate into plants to a limited degree, and can cause damage. Rapid 'scorching' (direct local injury) of leaves tend to occur in hotter climates.

Martin, 1964 and Tweedy, 1969, have suggested that sulphur itself is the primary toxicant, it must first be oxidized to sulphur dioxide or trioxide or to sulphuric acid, or it must be reduced to hydrogen sulphide.

The ultimate biochemical sites of action of sulphur and the basis of the special sensitivity of powdery mildew fungi have not been explained.

(B) Dinitrophenols :- Dinocap is second to sulphur in general importance as a powdery mildew fungicide. Dinocap was first synthesised as an acaricide. Dinocap is a mixture containing 65-70% of 2,6 dinitro-4-octylphenylcrotonate (dinocap-4) and 30-35% of 2,4-dinitro-6-octylphenylcrotonate (dinocap-6). (Kirby and Hunter, 1965; Byrde et al., 1966; Kirby et al., 1966).

Dinocap is formulated mainly as a 25% w/w Wettable powder or as a 50% w/y - emulsifiable liquid. High volume sprays applied at concentrations of 200-250 ppm dinocap at 10-14 day intervals at 100-125 ppm at shorter intervals. It is used widely on cucurbits. But is very expensive.

The dinitrophenols are all surface fungicides. Esterification to the crotonate and the addition of the octyl side-chain is some way confer specificity of action towards powdery mildew.

(C) Quinomethionate - Formerly known as oxythioquinox. It gives good control of powdery mildew, when applied in programmes of repeated sprays, such as currents, gooseberries, strawberries and cucurbits and it is used both in the glass house and the field. It is also more expensive and it can cause damage to some crops. Quinomethionate is a surface fungicide, having protectant, curative and autis sporulant actions, (Sasse, 1960).

(D) Drazoxolon - (Geoghegan, 1967) - It acts as a surface protectant, but it does exert, a good curative action against powdery mildews. Its biochemical mode of action is unknown.

(E) Ditalimfos - This organophosphorous compound. It is a surface fungicide and possesses both protectant and curative activities against powdery mildews. (Tolksmith, 1966). Its mode of action is unknown.

(F) Other surface fungicides - Fluotrimasole, halacrinate and nirtotalisopropyl are powdery mildew fungicides. Mainly

as sprays to control the cereal or apple mildew. Piperalin is used in the USA for the control of powdery mildew on roses and other ornamental plants.

Solution of various surfactants, or soaps, or even washing soda have some curative action on mildewed plants.

(G) 2-Amino-pyrimidines - Dimethirimol, Ethirimol and bupirimate (Systemic fungicides), these compounds are readily translocated upwards in the xylem, but are not moved out of treated leaves and are not transported downwards in the phloem. They can be applied to roots, either by soil incorporation or by seed treatments; alternatively they can be used as sprays.

Dimethirimol was introduced first, mainly for the control of cucurbit powdery mildews (Elias et al., 1968). One application of 0.25 g a.i. as an aqueous soil drench around the base of a large cucumber plant in a commercial glass house conferred complete protection on the whole plant for at least six weeks.

Ethirimol is particularly effective against powdery mildew of cereals (Bebbington et al., 1969). It is applied mainly as a seed treatment formulated as a 50% W/V aqueous

suspension. Ethirimol passes through the soil into the roots and thence into the foliage, which is protected from mildew for many weeks after sowing. Ethirimol is also used as a spray on wheat and barley.

Supirimate, a sulphamate derivative of ethirimol as a spray treatment to control mildew of apples, roses, cucurbits and other crops. (Bent, 1974; Finney et al., 1975). It is much less effective than dimethirimol and ethirimol as a root treatment. It is more active than these as a spray against certain powdery mildews such as those of apple and rose.

The pyrimidines have a direct action on powdery mildew fungi. They can inhibit spore germination in vitro. When applied to roots, dimethirimol and ethirimol exert effects at the surface of the leaves, inhibiting mildew development (Bent, 1970). Other effect include a "repellent" action on vegetative powdery mildew hyphae.

(H) Pyridine and Pyrimidine Carbinols - First noted by (Brown et al., 1967., [illegible]r et al., 1967). It is highly active against powdery mildews. Its translaminar action appears particularly good.

Gramlich et al. (1969) found excellent field control of several powdery mildews was obtained from sprays containing unusually low concentrations of fungicides.

Triarimol has been found not to affect germination of powdery mildew spores but to interfere with the development of haustoria (Brown, 1970).

(I) Benzimidazoles - The systemic fungicides contains carbendazim and compounds such as benomyl and thiophanatemethyl which are readily converted to carbendazin.

Benomyl gives protectant and curative control of powdery mildews in general, (Delp and Klopping 1968). It is translocated in the transpiration stream of the plant, it will move from the root to the shoot and from the base to the tips of leaves but not in the reverse directions.

For control of powdery mildews the benzimidazoles are applied almost entirely as sprays. These are repeated at the normal intervals used for surface fungicides.

(J) Morpholines - Dedemorph and tridemorph are two closely related systematic fungicides which are highly active against powdery mildews, (Pommer et al. 1969). The biochemical action of these fungicides is not under stood.

(K) Triforine - Triforine is highly active against powdery mildews. It is systemic, moving in the Xylem system , and has protectant, curative and translaminar effects.

(L) Pyrazophos - Pyrazolopyrimidine is one of the small number of powdery mildew fungicides which contain phosphorus. It is absorbed by foliage and sterms and translocated upward in the transpiration stream. Root uptake is relatively poor. Applied as sprays at 7-14 days intervals it gives good control of a wide range of powdery mildews (de Waard, 1974).

Mode of action of all fungicides appear to work by exerting a fungitoxic action, either directly or after conversion to another active products.

## MATERIALS AND METHODS

### SURVEY

Survey for the incidence of Powdery mildews will be made from different localities at Aligarh, where members of Umbelliferae are grown. The carrot will be surveyed in the western parts of U.P., Intensive survey however, will be made in Aligarh and adjoining areas, wherever, these crops are commonly grown. The severity of powdery mildew will be graded as under:-

No infection ( - ) = No visible disease symptoms.

Mild infection (+) = Pustules, few, small in size and scattered.

Moderate infection(++) = Pustules many, larger in size, tending to coalesce.

Severe infection(+++) = Big pustules covering almost the entire leaf area.

### IDENTITY OF THE PATHOGEN:

For identification of the pathogen, leaves of plants of umbelliferae infected with powdery mildew from different localities will be brought to the laboratory in polythene bags. In order to having inoculum for further studies,

seedlings of the respective hosts in cotyledonous or at 3-4 leaf stage, grown in autoclaved soil containing in 25 Cm. in sterilized clay pots will be inoculated. For inoculation, technique of dry dusting of conidia of the powdery mildew will be used (Schmitt 1955). Inoculated plants will be kept in separate glass house chambers at 17-22°C. In order to avoid mixing of the inoculum. The inoculum which developed within 5-7 days of inoculation will be used for further studies.

In the absence of cleistothecia mycelial and conidial characters were examined for the identification of the Powdery mildew. These characters included colour of mycelium in older pustules (Rodigin, 1936 and Yarwood, 1957), shape of conidia (Alcorn, 1968); Presence and absence of fibrosin bodies (Homma, 1937; Clare, 1958, 1964; Kable et al. 1963; and Jhooty, 1967) and Conidial measurements (Bouwens, 1924, 1927), and type of germ tube (Hirata, 1942, 1955; Kable et al. 1963 and Zaracovitis, 1965).

For determining the size, conidia will be measured for each of the different powdery mildews and the average range of size will be determined. For the presence and

absence of fibrosin bodies, conidia will be mounted in 3% aquous solution of KOH as suggested by Kable and Ballantyne (1963). Conidia will be germinated on glass-slides in humid chamber (Zaracovitis, 1965).

To study the size of germ tube, conidia will be dusted over dry clean glass slides placed on glass triangles in a petridish containing double distilled water. Later these will be transferred in an incubator running at 17-22°C. After 24 hrs, conidia will be stained in cotton blue and mounted in lactophenol for observations.

The size of the conidia will be determined by measuring 250 $\pm$ 20 conidia. In case the perithecia will be there, number of asci per perithecium will be examined. The measurements of ascospores, the size of ascospores will be taken into account.

## HOST RANGE AND VARIETAL SCREENING

For studying the host range, mature plants and seedlings of various of umbelliferae and different cultivars raised from surface sterilized seeds grown in autoclaved soil will be inoculated with conidia of Powdery mildew by drying dusting technique. These studies will be carried out in glass house as well as in the field.

The inoculated plants of different isolates will be kept in glass house chambers at 8-18°C. Inoculated plants will be transferred to separate glass house chambers and regularly examined for the appearance of disease. The inoculated plants contained in small pots will be transferred with entire soil to the pits earlier dug at a distance of 8-12 feet to avoid injury to the roots. Inoculated healthy seedlings will be also be transferred which will be served as control. Temperature in field will be in between 18-22°C at the time of tests. For each host-Parasite combination there will be five replicates.

After 20 days of inoculations, the intensity of di sease will be rated but over all rating will be categarise as:-

Resistant (R) = Mildew failed to appear.

Susceptible (S) = Mildew appears.

For studying the varietal response of different cultivars of umbelliferous hosts, inoculation tests will also be made on detached leaves and leaf discs (Morrison, 1960, 1964). Leaves will be removed from the uppermost nodes of healthy plants grown in clay-pots. Leaf discs will be cut with 1 cm. in diameter, sterilized cork borer and floated on water in petridish. The detached leaves on the other hand will be placed on glass triangles in a petridish with the petiole dipped in water, then will be inoculated with conidia.

Observations for disease intensity will be made daily for two to three weeks after inoculations. Throughout the studies the production of perithecia will also be examined. Whenever they will be produced, the time taken for the appearance of perithecia will also be recorded. Later on perithecia will be dissected and examine for the

presence of asci and ascospores. Following rating for disease intensity will be used throughout (Wheeler 1969).

| Grade | Description | Infection rating |
|---|---|---|
| Highly resistant | Plant completely free from infection. | 0 |
| Moderately resistant | Mycelium developing both on leaves and stem covering 26-50% leaf area. | 2 |
| Susceptible | Many small colonies appearing later Coa-leseceing and covering 51-75% leaf area. Mycelium developing on stem as well. | 3 |
| Highly susceptible | Entire plant covered uniformly by mildew. Percentage disease index will be calculated as follows:(PDI). | 4 |

$$\text{Percentage disease index} = \frac{\text{Total numerical rating}}{\text{Total leaves examined} \times \text{Maximum rating}} \times 100$$

## EFFECT OF DIFFERENT RELATIVE HUMIDITY AND TEMPERATURE ON INCUBATION PERIOD

To study the effect of temperature and relative humidity, surface sterilized seeds of susceptible cultivars of family umbelliferae will be sown in autoclaved soil contained in 10 cm. clay-pots. The umbelliferous plants in cotyledonous stage will be inoculated with conidia obtained from the original culture maintained in glass house and the inoculated plants were transferred in growth chamber maintained at different temperature viz., 5, 10, 17, 20, 22, 25, 30 and 35°C with 60, 80 and 90% relativel humidity.

At each combination of temperature and relative humidity, plants will be regularly examined for the appearance of the disease and the perithecia. The intensity of disease will be noticed after 7 days of inoculations.

A maximum period of one month will be provided in order to ensure the production of perithecia except in those where the symptoms will not appear. For studying

the effect of different relative humidities on conidial germination, super saturated solutions of the following salts will be prepared (Anonymous 1957).

| Super saturated solution of | Relative humidity % at 20°C |
|---|---|
| Sodium nitrate | 66 |
| Sodium acetate | 78 |
| Ammonium sulphate | 81 |
| Zinc sulphate | 90 |
| Sodium hydrogen phosphate | 95 |
| Double distilled water | 100 |

The solutions with supersaturation will be transferred to lower chamber of small dessicator which serve as humidity chambers. Freshly developed conidia of the same age will be uniformly dusted over the clean glass slides with the help of glass rod (Nair, Sadasivan and Ellingboe, 1962). The entire assembly will be kept at 20°C. After 4, 8, 12, 24, 36, 48, 60 and 72 hrs. of incubation the number of conidia that germinated and those failed to germinate will be counted and the percentage germination of conidia will also be calculated.

Paul and Kaushal (1985) observed that the effect of relative humidity on conidial germination of powdery mildew observed that the humidity of various powdery mildews varies and he divided them into three categories depending upon the relative humidity. He cosrelated the germination percentage of different powdery mildews ,with different relative humidities.

To determine the effect of temperature freshly formed conidia will be dusted over the dry clean slides, kept on glass triangles placed in the petridishes containing double distilled water at the bottom and transferred to incubators. Each running at -5, 5, 10, 17, 20, 25 and 30°C. After 4, 8, 12, 24, 36, 38, 60 and 72 hrs. of incubation, slides will be examined for germination of conidia as mentioned above.

To determine the role of ascospores in the recurrence of disease, perithecia, if observed, will be subjected to the following treatments:-

The conidia that germinated and those which failed to germinate will be counted. There will three replicates for each treatment.

Leaves and stem portions containing perithecia will be (a) burried for 270 days in small terylene bags; (b) these will be kept in plastic tubes and transferred if in different temperature cabinets each running at -5°, 5, 10, 17, 22, 25 and 30°C. These tubes will also be given a treatment of low and high temperature alternately for varying periods.

For each treatment plant material having perithecia will be fixed to the inner portion of the humidity chamber, the base of which either had slides on glass triangle or the floating leaves of family umbelliferae at the base (Schnathorst, 1959).

The ascospores will be tested for their germination, on the lines suggested for conidial germination.

The whole assembly will be transferred to the temperature cabinets running at seven different temperatures and six combinations of temperatures.

In each case untreated infected plants will serve as control.

CHEMICAL CONTROL

The systemic fungicides such as benlate, calyxin will be tested for the control of Powdery mildew of umbelliferous plants. The effect of these will be studied to control the germination of conidia as well as the development of disease. The different concentrations of the fungicides will be 0.00001, 0.0001, 0.1, 0.2, 0.5 and 1.0 percent respectively. will be tested on germination of conidia.

The umbelliferous plants will be treated weekly (in each groups), fortnightly and monthly within different concentrations of the fungicides tested both as spray. After the final treatment as observed by Munjal et al. (1963) and Srivastava et al. (1971) that in case the severity of the disease will be recorded in seven days. The disease severity will be graded on the basis of intensity of powdery mildew as mentioned below:-

Disease control Index

$$= \frac{\text{PDI in control} - \text{PDI in treated}}{\text{PDI in control}} \times 100$$

By this formula the disease control index will be calculated.

The plant will be inoculated with powdery mildews and treated with fungicides.

(A) The plants will be first treated with fungicides and then inoculated with mildew after eight days.

(B) The plants will be treated with fungicides after symptoms of powdery mildew developed.

To find out the difference in sugar and nitrogen contents of healthy and infected plants respectively, the present estimations have been taken into account.

Estimation of sugar:

The samples of umbelliferous plants will be suspended in 3 ml warm 95% ethanol and ground with mortar and pestle having some quartze sand and heated in boiling water bath for 2 minute. The volume will be made upto 15 ml. with warm ethanol and kept as such successively extracted with 60% followed by 30% ethanol and finally with distilled water. The super saturated solutions will

be pooled together and the volume made upto 30 ml. with 95% ethanol and subsequently reduced to 5 ml. water bath (AO AC, 1960; Bell, 1955; Nelson, 1944; and Somogyi, 1945).

To one ml. of 10 times diluted above aliquate, 1 ml. of freshly prepared somogyi reagent will be added. The mixture will be heated for 12 minutes in a hot water bath and then cooled in tap water. To this, 1 ml. of arsenomoly bate reagent will be added. The blue colour developed will be diluted by the addition of 50 ml. distilled water for recording optical density at 494 nm. in spectrophotometer. The concentration of reducing sugar will be calculated using a standard curve with different concentration of glucose.

For estimation total sugar to one ml. of diluted extract (extracted for reducing sugar) 1 ml of IN $H_2SO_4$ will be added. The mixture will be heated at 49°C for 30 minutes to hydrolyse non reducing sugar. After cooling the acidity will be neutralised with N. NaOH. Optical density will be recorded at 495 nm. in spectrophotometer and concentration of total sugar will be calculated using the above standard curve. There will be five replicates throughout the studies. The data will be subjected to statistical analysis.

Estimation of nitrogen:

The aerial part of infected and uninoculated plants will be dried for 48 hrs. at 60°C in an over and later ground in pestle and morter for N estimation for the former, the portions showing powdery mildew symptoms will be selected.

The dried and powdered sample (0.5 gm) will be taken into a 500 ml. Kjeldahl digestion flask. Subsequently sodium sulphate (20 gm.) plus catalyst digestion mixture will be added. To this 35 ml. of concentrated sulphuric acid will be poured by scissling the flask and subjected to digestion till the organic matter in digested bearing the solution clear. The digestion flask will then be cooled to the point when crystals starts to form and then 300 ml distilled water will be added.

Seperately 25 ml of 4 percent boric acid will be pipetted into a conical flask (500 ml) and 4 drops of bromocresol green methyl red indicator solution will be added. A glass receiver tube will be attached to the flask

neck so that the bent end is submerged in the boric acid solution contained in the flask. The outer end of the tube will be attached to the condenser.

The Kjeldahl flask containing digested plant material will be fixed on the distillation stand at 45° angle and connected with the condenser. About 125 ml. of 40 percent NaOH will then be poured and the distillation flask will be heated for 45 minutes followed by disconnection of the receiver flask. The contents will then be filtrated against standard hydrochloric acid.

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*originals not seen.